DANNY LENNON: Dr. Herman Pontzer, welcome to the podcast, and welcome back, I should say.

HERMAN PONTZER: Yeah, thanks for having me, always fun to be here.

DANNY LENNON: We've delved into your work previously on the podcast, and we're going to go a bit more deeply into that as well, and I know a lot of people within academia have had a lot of interest in your work. But now with the upcoming release of your book, this is obviously written for an audience that extends beyond those directly in academic circle, what was it that made you want to write this book at this particular time?

HERMAN PONTZER: It's been really fun doing a lot of this work on metabolism and human energetics over the last few years, as you know my work sort of takes an anthropological view, looking at variation in diet and exercise and lifestyle in general, and trying to figure out how that affects how we burn calories and all the sort of repercussions for that for our physiology and our health. And I've had a lot of fun doing that work over the last 10 or 15 years or so, and a lot of fun and interesting discoveries that have been fun to share with my academic colleagues and folks in the medical world. But as I've had a chance to do that, and give talks on this stuff, and I’ve written a couple of popular pieces as well for Scientific American and stuff like that, it's been really, really fun to get engagement back from sort of the broader audience, the folks who, like you say, they're not in academics, they're not in health, but they're interested in how their bodies work and how this applies to them and how this applies to big societal issues like obesity. And in those conversations, one, it's just really fun having those conversations and engaging with that broader audience. But it also was really obvious to me how poorly people have been taught how their metabolisms work. There's just such a lack of understanding at a basic level, and it's because we don't really teach it, maybe you get some of the Krebs cycle or something like that in high school biology; but for most folks who don't do this stuff for a living, even the fundamentals about how carbs and fats and proteins are digested and turned into tissues or burned for energy, even that basic stuff isn't well understood, and it's not through any fault of people's own fault. I think, again, people are generally taught in schools very well, and if you were to pick up your typical health magazine, and get your education that way, oh my God, I mean, it's kind of stunning what people can get away with in this world of metabolism science or what passes for it in the popular press. And so, it just felt like a really good opportunity. We've been doing this work for a while. We have a couple of really fun, I think big discoveries to share, and there seems to be, in my opinion, this need to do it correctly and get the real science out there in a fun, digestible way. So all of that led me to write this book.

DANNY LENNON: Yeah. And I think that's the thing, something that is so poorly misunderstood, but yet, the term metabolism is so often used colloquially in everyday language that everyone talks about it. So I suppose as a two-part question maybe just to set the stage, so everyone is on a kind of level playing field here, number one, can you maybe give, what is the best way to conceptualize what actually is metabolism; and then maybe off the back of that discussing, what are some of those common misconceptions or incorrect definitions people typically go to when they think of what metabolism is.

HERMAN PONTZER: Yeah, that's right. So metabolism, the sort of simplest definition that's honest, would be it's the work all of our cells are doing every minute of the day to keep us alive and accomplish all the physiological tasks that our body's trying to do. And so you've got 37 trillion cells, and they're all busy right now as you're listening to this, doing all their different jobs, and most of those tasks you're completely unaware of, like, maintaining the right balance of charge in your neurons, and making sure that your immune system's battling whatever it thinks is invading, and digesting your food if you just had lunch, and all that stuff, you're not really aware of any of that. But all of that is the work that your cells are doing, and all of that work requires energy, right? You can't get anything for free. And so, when we think about metabolism, or I think when you look at the typical supermarket magazine cover, self-help thing about that metabolism, it's all about exercise, right? Or maybe it's about some dietary hack to boost your metabolism, whatever they think that means. And people try to think about it then in terms of energy expenditure, which is that's a fair start, again, all the work that our cells are doing, that ends up being calories burned. But it's not just exercise, right? And so we focus on exercise, and we – I think, we forget about all the other things our cells are doing, all the other things our bodies are doing, and of course, as an evolved organism, we're not evolved to exercise, like any other species, we're evolved to reproduce and survive. And so, that evolutionary perspective and that kind of more holistic perspective, I think, helps to begin to explain how, in some ways, how complex the system is and how integrated it is, but also how these parts work together, and how it's not as simple as something like, well, exercise equals calories kind of thing.

DANNY LENNON: One of the things that you've already mentioned that has been a key to your work over time that I think has been very informative and refreshing for people is that you're obviously coming at many of these ideas from an anthropological perspective, and you've done an extensive amount of work in that area. I do want to ask about some of that particular point, and I know you've done, obviously, a lot of work with the Hadza, but to maybe lay the groundwork, can you explain to people a bit about the Hadza, maybe a bit about what their societies are typically like, and maybe how that may differ from the stereotypical view we may get portrayed of what hunter gatherers' current existence is like?

HERMAN PONTZER: Yeah, that's right. So all humans were hunting and gathering up until just a few thousand years ago which is a blink of an eye evolutionarily and evolutionary changes slow. Our bodies are still sort of set to hunter gatherer mode in a way. And so hunting and gathering is this lifestyle, it's this catch all term, and there's a lot of different ways to be a hunter gather. But basically, hunting and gathering means that you don't have any domesticated crops or domesticated animals or machines or guns or anything like that, electricity; and instead, you are getting your food from the wild game and plants around you. And so, the Hadza are a community of folks in Northern Tanzania who live that lifestyle and have for, as long as anybody has any kind of records for it. And so they represent just sort of one way to be a hunter gatherer just in the same way that there's a 1000 different ways to be an industrialized human or a farming human. There's a 1000 different ways to be a hunter gather, or there used to be anyhow, there are very few of these populations left that still hold on to those sort of traditional ways. But the Hadza live in Northern Tanzania. It's a pretty semi-arid, dryish Savanna kind of habitat. They live in a fairly intact ecosystem, and so they have the full variety of wild plant foods to eat, Baobab fruits and berries, wild tubers that they dig up, men hunt for wild game, and so that includes zebra and Kudu and other antelopes, warthogs, all sorts of whole variety of animals. Men also gather a lot of honey, and so, it's really – having had a chance to go and work there, which, as you say, we started that work, well, people have been working with the Hadza literally for decades, my first season, that was about 10 years ago now. And I was interested in going there to measure metabolism, energy expenditure from a kind of ecological evolutionary perspective, because here we have this community that's this wonderful opportunity to ask the question, what life like – if a human grows up as a hunter gatherer, what's that look like? But it was also really informative in all the little ways that you begin to understand what hunting and gathering is like, and it's not the sort of cartoon version that we often hear about today. So that was great. First thing you notice is that they eat a lot of honey. So this idea that paleo or hunter gatherer diets mean no sugar is blown out the window by your first afternoon in the Hadza camp.

DANNY LENNON: Yeah, and we'll definitely maybe touch on some of those misconceptions related to ancestral diets later in this discussion. There's so many aspects as I was reading through your book that are just fascinating, even before we get into directly how metabolism influences body composition, diet, exercise and so on. And one towards the start of the book that you mentioned was how humans are different to other mammals in our growth and development rates, where we're kind of basically the outliers, whereas often we think of other creatures being strange. Can you maybe first explain that?

HERMAN PONTZER: This gets to this point we started off with, which is that metabolism isn't just about exercise, metabolism is absolutely everything. Everything that your body does, burns calories and so it's all metabolism in a way. And it turns out, this is one of the discoveries that I was lucky to make with a bunch of colleagues and collaborators, of course, a few years ago, which is that when we look at how many calories humans burn – and actually not just humans, but other primates too, so this is the other apes as well as monkeys and lemurs and lorises, all primates, it turns out, as a group of mammals, we have low metabolisms. We don't burn many calories every day for how big we are compared to other mammals. And so, that slow metabolism, what does that mean? Well, it means that our cells are working more slowly. That's what it has to mean, and it turns out that that seems to relate to the fact that we grow slowly, we reproduce slowly, and we age slowly. And so, we think about sort of the normal human life course as, okay, nine months of gestation, and 13 years of growing up to reach maturity or maybe 20 years depending on how you want to measure it; and then you've got your reproductive lifespan that's done by the time you're 60 or so, and elderly and old age, and maybe if you're lucky, you might live to be in your 70s, 80s or even 90s. That's a normal human lifespan, but that's incredibly slow. That's a really slow lifespan. Right? And so your dogs and cats that we all like, if you grew up with pets or you had friends who did, you know, gosh, you're lucky if a dog makes it into his teens. Right? And why is that? Well, because like most animals, like you say, they're the normal ones, we're the odd balls – most animals grow much more quickly, and that's because just their whole systemic metabolic rate, all their cells are just set to a higher rate of work, and so they burn calories faster. And why are they burning calories faster? Well, because their cells are working faster, and that results in faster growth and faster reproduction, and we think a faster sort of aging process as well. So metabolism is absolutely everything, and I wanted to get that – I'm glad you brought that up, because again, it's not just about exercise metabolism, it's absolutely in every aspect of our life. And when we understand that, again, I think it helps sort of broaden our minds about what we're talking about.

DANNY LENNON: So given that we have, humans have essentially evolved to have this kind of slower metabolism relative to other mammals, there must be maybe advantages to that, and there also must be advantages to the faster metabolism other mammals have evolved to do. What are maybe some of the pros and cons that have driven that from an evolutionary perspective?

HERMAN PONTZER: Right. Well, so primates in general have a low metabolism. Now, when you sort of zoom in on just the apes, right, so that's humans and chimpanzees and gorillas, then we can see that compared to our ape relatives, we are actually a little bit faster than the others. And so, that's the perfect place to ask this question, like you brought up, what are the advantages of going slow, because there's a whole group if we're going slow. And what are the advantages of going fast, because in our specific branch of the primate tree are one lineage we seem to have gone a little faster. Well, slow metabolism, again, they seem to stretch things out and give you a longer, we associate with longer lifespans. Well, what can you do with a longer lifespan? You can spend more years learning, right? So if you're a creature, like a lot of primates are, that depends on its wits and learning and what it's learned over the course of its life to be a better and more successful creature, then a longer lifespan is good that way. You also can kind of weather, you can weather bad periods easily, more easily. If you're a mosquito, and you've got a couple of weeks to live, and those happen to be bad weeks, too bad. You're done. That’s no good. Whereas a human, a couple of weeks, you can weather that pretty easily. So there are advantages to that. There are disadvantages though, because if you grew up slowly, well, from an evolutionary point of view, you take the risk of getting killed before you reproduce at all. So there are disadvantages there of just taking your time, we call that an ecological risk, where an evolutionary risk of dying before you get the chance to reproduce. And so, that's not good either. So again, is this kind of push and pull, in that the balance of that is sort of where evolution leads you in your particular context as any given species to where they are today. So we can think of every species alive today as sort of the most recent, you know, their metabolism and their physiology and their strategies are sort of the most recent chess move that evolution has made for them as they play this big game of life.

Now, humans are fast, so all primates are slow, but then humans are fast compared to other primates. Right? We're still slow in general, but we're faster than chimpanzees, for example. Why is that? Well, that seems to reflect this need, this element of the human strategy, that is costly, which is compared to other apes, we have big babies, right? Babies are costly to produce, energetically costly as well as, these days, financially costly, but energetically costly. Having a big brain is costly. I mean, our brains are so big that as we're sitting here chatting every, something like every fourth breath that we bring in is the oxygen just to feed your brain. It's incredibly energetically expensive. And if our brains weren't so darn big, then it wouldn't be that but of course that is. We have a physically active lifestyle, and that could contribute to the fact we need to be able to have a faster metabolism to be able to maintain that or active lifestyle because hunting and gathering is harder work than just the gathering that apes do. So yeah, it's been really interesting to sort of try to reconstruct the evolutionary pressures that kind of pushed and pooled metabolic rates and made us who we are. I can say that we didn't have the metabolic rates that we had. If we had a really fast metabolic rate, like a dog, life would be so fast, it would be unrecognizable for us. You'd be a grandmother by the time you were five years old or grandfather. If it was any slower and we didn't have a metabolic rate to support these big brains, well, then we'd be – we wouldn't be having this conversation over satellite internet connections, and all this complicated technology. So it really is kind of the unseen framework that has made life what it is for our species.

DANNY LENNON: And that's what I find so fascinating, and how evolution and biology sheds light on so much of this interesting stuff. And in fact, as someone who's a fan of just learning about biology, generally outside of my own sphere of expertise, I've found so many parts of the book really interesting, and one of those that you touched on and maybe aware of things I hadn't ever considered, never mind known before, about topics I'd heard was kind of two landmark events. One you kind of talked about oxygenic photosynthesis and changes in the earth due to increasing oxygen, and then this incredibly important and improbable evolution of oxidative phosphorylation, which I think many people listening may have heard that term, either from biology in college or people in nutritional science will know that term. So can you maybe just describe an overview of those two landmark events because I found that fascinating to think of that and how it just explained so much.

HERMAN PONTZER: Yeah, I am fascinated by this stuff too, which is why this has been my life's passion, and is to do evolutionary biology and particularly for humans, but all of it I think is just completely mind blowing away how old the earth is and how old life is and how all of this stuff sort of got sorted out over these deep evolutionary time. When you look outside your window and you see all those plants cooking away, doing all of their photosynthesizing, if you're mean, you like to be outside, you like the nature that kind of gives you this warm, fuzzy feeling, because here are all these plants that are taking sunlight and carbon dioxide and they're putting them together and they're making energy out of that, out of carbon dioxide and water and sunlight.

And as a byproduct they make oxygen, and isn't that so amazing and wonderful that they make this oxygen for us to breathe, and gosh, it just feels, like, it warms your heart. But actually, so photosynthesis is the first, one of the first kinds of metabolism that evolved on the planet, and it gets going around 2 billion years ago or so or even more. And what happens is oxygen, so you get all these plants – there's no animals yet, there are certainly no animals that are breathing oxygen yet, using oxygen yet. You get all these plants taking off, photosynthesizing organisms – I don't know if you'd even call them technically plants at that point, it's so early on in life's early stages, algae and that kind of thing – and you're making, they're making oxygen, and they're incredibly successful, because they found this way to harness sunlight. And it takes off and it goes gangbusters for hundreds of millions of years, but what happens is that oxygen byproduct that we think of, as this really great cornerstone of life, is building up in the – first build up in the oceans. Then it builds up in all of the soils, everything that can absorb oxygen, and then it builds up in the atmosphere, and it is slowly killing everything. Actually, we call it – the great oxygen crisis is what paleontologists called this, and you get these great rusted beds of ferrous soils that have now compacted into rock, of course; and you get basically the potential to snuff out all life on Earth, because the plants are producing this poisonous stuff called oxygen.

Again, we think about it as a good thing, but oxygen is actually this really destructive thing. Right? How do fires work? How does rust work? Well, it's oxygenation. And so, what you have is the sort of poison permeating the globe, and amazingly, you get microscopic organisms, bacteria that figure out how to use the oxygen to make energy themselves. And so, you have to think about all the quadrillions of failures of lots of the microscopic organisms that didn't use oxygen, didn't have the right mutations, but eventually, the right set of mutations evolved, which is another sort of eye opening thing to think about, it was a deep time, and how many quadrillions of opportunities life would have had to evolve this. Anyway, you get bacteria that can finally evolve, that can use oxygen, the aerobic bacteria. We still have some aerobic bacteria today, around a bunch. But then one of those aerobic bacteria gets eaten by another cell, and now all of a sudden, you've got, instead of digesting that bacteria away and it just destroys it, that bacteria goes on living in the cell and now that cell that ate the bacteria can harness that bacteria like a little power plant, and now we call those mitochondria. Right? So the mitochondria are actually that we all depend on now to use for oxidative phosphorylation, like you said, to be able to do aerobic metabolism to use oxygen, all have this ancient, a couple of billion year almost year old history of life on earth and sort of improbable set of events. Of course, we only think it's improbable because we're here to appreciate it. But, yeah, so little things like that, like you say, it was really fun to kind of revisit for this book and look at that history discovery, because it's just so much fun.

DANNY LENNON: And in a weird way, it allows us to have gratitude for what we have given how improbable our existence is, when we look at some of these things, the piece about mitochondria was particularly fascinating. I actually highlighted a line from your book, which I just thought summed it beautifully. It said, “all the work our bodies do is powered by microscopic alien life forms called mitochondria living within your cells. Mitochondria have their own DNA and their own 2 billion year evolutionary history, including saving all life on Earth from certain doom”. I just thought that was perfect. It's one of the best descriptions I’ve heard of mitochondria, and I think it'd probably be more engaging than just it's the power house of the cell, which is the only thing I think people remember typically from the biology in school.

HERMAN PONTZER: That's right. Next time, you're sort of getting droned on about mitochondria or your eyes are rolling back in your head, just appreciate it for a moment that, like you say, they saved all life on Earth, we wouldn't be here. We'd all have been popped out in an oxygen catastrophe.

DANNY LENNON: Before we talk about some of this specific stuff related to energy expenditure, maybe talk about some of the nerdy details for those that are interested in research. When it comes to measuring energy expenditure, we have various methods of doing that, we can look at direct colorimetry, indirect calorimetry, can you maybe just make that distinction for us and kind of talk through how we currently measure energy expenditure, and maybe what is the best, “way to do so”?

HERMAN PONTZER: Sure. So people talk about direct calorimetry or indirect calorimetry, people might have heard those terms. And so a calorie is a measure of heat, right? A measure of energy, but often done as a measure of heat. And so, you can use that to help you understand what we're talking about. Direct calorimetry is when you directly measure the heat that an organism gives off. You have to do this in a laboratory setting, of course, because you have to sort of capture and measure all the heat that's produced, and that's technologically a challenging thing to do. And so, what people typically do instead is what's called indirect calorimetry. And so when we're measuring oxygen intake or carbon dioxide production, then we're not directly measuring the heat, we're measuring some of the fuel that's being used and the output of that respiration, the CO_2, and so we're indirectly measuring the heat production. And so, indirect calorimetry is when we measure oxygen consumption and carbon dioxide production. That's typically how we do it. And that's, if you go to a doctor's office, and you hang out under a hood for a while, it's measuring your breath, that's what it's doing. In our lab, we have different ways of doing that surgical mask based thing that measures breath by breath, how you're using oxygen and making CO_2. There are isotope tracking techniques that can be used as well, that allow us to track CO_2 production, but that's all indirect calorimetry. And anything else is guessing. So in your Fitbit, for example or your Apple Watch or whatever smartphone you've got – I just bought a bioimpedance scale for my home just for fun. It tells me what my BMR is every day, it doesn't actually know. All those devices, what they're doing is they're making estimates, based on some previous studies, let's hope, of how either movement relates to calorie expenditure or, in the case of your bathroom scale, if it's a smart scale, your bodyweight and maybe your body fat percentage and your lean mass, how that relates to energy expenditure. So those are all the different ways you'll often see expenditure talked about.

DANNY LENNON: So that kind of sets the stage to tie some of these different ideas that we've already discussed together, and I think one of the most influential areas of your work, certainly as it relates to metabolism, has been the constrained energy model, which I know we discussed some of that previously, and I think there's definitely a lot to dive through there. So maybe before I ask any specific questions on that, what is the way you typically tend to summarize that for people who are hearing about that concept for the first time?

HERMAN PONTZER: The simplistic way, or let's say, the simple way, simplest way to talk about the constraint energy theory is that our bodies try to maintain the total calories you burn every day within a narrow range in the same way that our bodies try to keep our body temperature within a narrow range, try to keep our blood sugar levels within a narrow range, your body is also trying to keep total energy burned every day within a narrow range, and to do that, it has to be adaptive. Right? So if we change our lifestyles, if we burn more energy on exercise, because we pick up a new exercise program, well, the only way to keep daily energy in check is to sort of reduce energy expenditure on other things. And so, that sort of juggling act, that dynamic juggling act that our bodies are doing beneath the surface, is the sort of the interesting nuts and bolts of the constraint energy idea. But a top line answer is, it's just your body keeping energy expenditure within a narrow range.

DANNY LENNON: So if we have increasing physical activity, but at a certain point, not necessarily, a linear increase in total energy expenditure at that point, there has to be some compensation from another factor that contributes to energy expenditure. Do we know exactly where that is coming from, what aspect of energy expenditure is decreasing to account for that?

HERMAN PONTZER: No. So what we have a lot of interest in right now is exactly what's changing. So the work that you mentioned before that I've done with the Hadza hunter gatherers, they're incredibly physically active as you can imagine; you must be, to be a hunter gatherer, you walk a lot, you work a lot; they have the same total daily energy expenditure as you and me, even though we're much less active. Other populations as well that we've looked at now. So there are populations like the Shuar in Ecuador, the Chimane in Bolivia, these are really physically active traditional populations, same energy expenditures as you and me. Amy Luke and other folks have done work on this and other populations across the planet. We've looked at this within populations as well. More activity does not mean higher energy expenditure. So what's happening then, is this widespread phenomenon that all humans seem to share is that we're adapting, and we're turning other systems down, we have to be. Now, what are those systems? There are a couple of different options. One is you can sort of change the way that you're acting, that you behave when you're not exercising, right? You could change what people call, sometimes they call it NEAT, non-exercise activity thermogenesis, things like fidgeting or standing instead of sitting. And those kind of behavioral changes that are subtle and would be hard to pick up with the ways that we typically measure activity, which is usually like a smartwatch or a hip worn accelerometer, those small behavioral changes that we might miss when we measure somebody's daily activity, could help explain sort of what's compensating when the sort of overt activity is increased.

There are reasons to think that there's not enough NEAT out there to explain all the compensation that's going on. So what we think is going on as well, in addition to NEAT, and maybe might even be more important than changes in NEAT, are changes in all the other tasks that your body does. So we started off this conversation talking about how metabolism is everything, right? It's all the systems that our bodies do. And actually, even if you're really physically active person, the large bulk of your calories every day are spent on things that are not physical activity. So there's lots of potential there to adjust other expenditures, and make room basically for exercise. And so, things like reducing immune system activation, things like reducing energy investment in reproduction, things like reducing energy expenditure and stress reactivity, and we actually have good evidence, epidemiological evidence that all those things are happening. So when you exercise, people who exercise we know have lower inflammation levels, inflammation is sort of unnecessary immune activity. We know the people who exercise have lower stress reactivity, they don't produce as much epinephrine or as much cortisol in response to psychosocial stress – and epinephrine and cortisol raise your metabolic rate, so if you produce less of those, you're burning less energy on that, and you could make room that way then for activity.

People like the Hadza, right, so there are lots of populations that like the Hadza, the people who've worked with, that are these traditional groups that are really physically active. You would think, it is a hard life, those folks are tough as nails and also super cheerful and generous and wonderful to work with. But man, they are tough, and you might think, yeah, I would have thought, working with the Hadza, that if you measured a Hadza man's testosterone levels when he's going off and literally chasing lions off of a kill, in the morning for breakfast, that his testosterone levels, we might think, it would be higher than mine, but in fact, testosterone levels in a population like the Hadza are only half of what they are in the US. And so, there seems to be less sort of reproductive investment as well. So all of those physiological changes would save energy. It all fits together with this idea that physiological changes are happening to make room for exercise. But what we don't have yet and what we're trying to get right now, actually, we have grant applications in, we're trying to look into this is to really kind of follow it all the way through to get somebody who's sedentary, get them exercising a lot, and watch all the switches get turned on other systems to watch that process happen. That’s in the works, and I hope I can come back in the future sometime not too long and talk about that fun work. But right now, we're sort of in the discovery stage still with a lot of this.

DANNY LENNON: And I think that's what makes this model so interesting, because I think when people first hear about it, we tend to draw parallels with typical adaptive thermogenesis that occurs in response to say, dieting, and people know that you decrease someone's caloric intake, you have this suite of metabolic adaptations that changes their energy expenditure, and much of that is typically explained by changes in NEAT. So people, I suppose, the first conclusion we may jump to is, well, maybe that's the same thing going on here, but it does seem to be different mechanistically at least, or at least not been able to explain it in the same way, as those metabolic adaptations we get to say reducing calorie intake or the same in the reverse side if we increase food intake, we get this adaptive thermogenesis too. But it seems like it's slightly different to that.

HERMAN PONTZER: Yeah, we'd love to know actually, so another thing I talk about in the book is, like, as you're saying is diet is metabolic responses to changes in energy intake, not just exercise. And we got Kevin Hall study with the Biggest Loser program which people know about it, and lots of other science too showing that if you starve somebody, their metabolic rate goes down. And so, well, what's going down? Well, again, everything. You've got all these opportunities in your body to sort of adjust metabolic expenditure in different tasks. It will be fascinating to know what the similarities and differences are in the physiological response to dieting and the physiological response to increased exercise workload, because in some ways, the whole body systemic look of it is similar. Right? You can get lower inflammation, for example, with dieting as well as with exercise. So it'd be interesting to know how they're different and how they're similar, but I'm guessing, well, I don't know what I'd expect exactly. I think there's just a lot to discover there.

DANNY LENNON: Since putting this model out into the academic community, I'm sure you've had many a conversation and many different discussions with people who have maybe offered critiques or counterpoints or maybe potential challenges to the model. I'm just wondering, after this number of years, what do you feel are the strongest ones that you've heard so far?

HERMAN PONTZER: Yeah. Well, I think the strongest critiques are always born from the data, just like this model came from the data, the strongest critiques are from the data. And so people will say, well, look, if you look at this exercise intervention or that exercise intervention, we did see an increase in people's energy expenditures over four weeks or eight weeks. And so, that suggests that either we don't always see increases in energy expenditure, sorry, we don't always see a tight regulation of expenditure or there are cases where the body doesn't adapt. And so, people are always very interested to sort of try to understand that, and, of course, challenge me on it, which is great, that's how science works. What I can say is that, if we look at those challenges, if we look at exercise intervention studies that do show sometimes small increases in expenditure, typically, those increases are much less than we'd expect just from the exercise. So even when we see an eight-week study where people are burning 100 calories more a day than they were at the start, well, okay, that's interesting, but their exercise workload is 200 calories a day. Right? So somehow their body is, just in eight weeks, has figured out a way to save 100 calories a day, that we might otherwise not expect to be able to save. And I think the other issue is that all of these exercise intervention studies we have this mindset where a typical intervention study could be a couple of weeks, in that, quote-unquote, long term one might be a couple of months. But life is long, right? Human lifespan is 76 years. You spend 15 years of your body developing in your environment and figuring out listening to your diet, listening to your exercise and developing to an adult human. So I think we need longer term studies, because the longer we go, the longer the duration of the study, the more and stronger evidence we see, in my opinion, based on average studies, for exercise, sorry for metabolic compensation, the expenditure. So I think, if it's a study, that's a couple of weeks long, yeah, you're going to see any range, whole range of possibilities. If you get out a few months and what we haven't done yet, we should do, get out a couple of years, I would expect, this is my prediction, we can test it, you're going to see a lot of metabolic compensation out that long.

DANNY LENNON: Because, I suppose, that's the exposure of interest to us really over what's happening over a longer time course, because the shorter we make that interval, then, I suppose, we're kind of getting away from the actual hypothesis you're putting forth, so like, I remember seeing some data on, it may be firefighters and like a 100-mile racers, and like on one individual day, they could get up to like 15-16,000 calories expended, but that isn't really fitting into, well, what is the adaptive impact of ongoing exercise over time. It's just a different question, I suppose. We know in relation to, say basal metabolic rate, there's often a pretty big inter individual variation between people, even for a given body size. Do we see the same type of variation when it comes to this constrained energy model, in that, that point where people start to see that kind of plateauing off of energy expenditure, does that point happen earlier or later in different people, do we know what that variation looks like if we know at all?

HERMAN PONTZER: I don't think we know. Now, you're absolutely right, that people can vary by 2 or 300 calories a day, even more than that, in their basal metabolic rates, even for the same body size, composition, everything. The same is even more true in total energy expenditure. So we use isotopic tracing methods to measure calories a day. So this is an estimation, and we do that in an indirect calorimetry method. We see that two people same build, same gender, everything, same age, can differ by 3 or even 500 calories a day, in how many calories they're burning. And I don't think we know why that is very well, honestly, I'd love to be able to design the study to do that. It'd have to be a large study, because there's enough variation that you have to enroll lots and lots of people. I'm actually part of a big doubly labeled water international sort of database effort to kind of to ask those kinds of large scale questions, and hopefully, we'll have answers sometime. But no, I don't think we know even what that sort of background variation is due to. And so then the second question would be, and where's everybody's plateau point, where's everybody's break point, where's everybody's competition point, well, that's the next question. So we don't even have the first question yet. So I don't know how to answer the second one for you.

You brought up the firefighters and the ultramarathoners. That was another fun thing. Constraint energy expenditure doesn't mean that you burn the same number of calories every single day. Right? That's not the timeframe, like you say. If you run a marathon tomorrow, you're going to burn more calories than if you don't. And so another thing we get into in the book is what is the one-day, two-day, one-week, two-week limits of expenditure, and so exploring that's been kind of fun as well. And how far can you push this, because over short periods of time, of course, you can push a lot; if you couldn't, there be no Tour de France. So you absolutely can push it over the short term. When we talk about compensation, we're talking about sort of lifelong multi-year kind of adaptation to your environment and energy expenditure.

DANNY LENNON: There's so many facets to this and different topics we could explore, and we're coming up on time now, so is there anything that you are particularly keen to highlight or think that we didn't suitably address that's related to anything we've discussed here or that you just like to mention before we start wrapping up?

HERMAN PONTZER: No, I would just say that this book is – we talk about diet, I talk about exercise, but I'm not trying to sell anybody a diet or an exercise program. I wish that the discussions that you see on social media, in the public on metabolisms, I think is a crucially important subject. Obesity, overweight, metabolic disease, they're all centered around how our bodies burn calories, and there's just so little good information out there in the public I think. So I'm not trying to sell anybody a diet or an exercise program, but I'm trying to get people to understand how the principles of how all diets work, and how all exercise programs work and how diet and exercise are really two different tools with two different jobs and you need both to be healthy. So I hope people take away from that sort of, in some ways, the book talks about all the different ways you can be healthy. There's not any one way. Humans are adaptable, flexible creatures, and so this book, I hope, will give people a lot of different ways to think about how to stay healthy. And I hope it's fun too, I talk about the work with hunter gatherers and archeological digs, and working with primates, and it's just a lot of fun to do all this work, and a lot of wonderful collaborators. And so, I hope the fun of it comes through as well, and it was really fun to make the book and to do the work. And so, sharing that is another big bonus than getting to write this book.

DANNY LENNON: Yeah, and I think you've done that, as I said to you before we started recording, I think not only is the book very engaging, but you did a great job of weaving in stories throughout this. It's not some sort of dry physiology textbook, so I think he did a fantastic job of balancing that out. So for people interested in the book maybe just remind them the title of the book, and then anywhere else online you'd like to send their attention or where they can find you and your work.

HERMAN PONTZER: Absolutely. So the book is called Burn. It's published by Penguin Random House, so it should be available wherever you are looking for books. I believe there's an audio version that's going to happen, so if you don't like to read, you can listen. And if you want to find out more about the Hadza people who we feature prominently in the book, I would encourage you to go to hadzafund.org, and learn about the Hadza, and in ways you can even help them out if you feel so moved. And if you want to find out more about the work I'm doing, there aren't a lot of Herman Pontzers in the world, so a quick Google and check on the Duke website,, Duke University is a great way to keep up with what we're doing and always looking to engage and talk with people and hear what they have to say. So please, let us hear from you.

DANNY LENNON: So that leaves us on the final question that I always end the podcast on. And this can be completely divorced from anything we've discussed thus far. It's simply: if you could advise people to do one thing each day that would have a positive impact on any area of their life, what might that one thing be?

HERMAN PONTZER: Get outside, the world's better out there.

DANNY LENNON: It is a great way to finish. And with that, Dr. Herman Pontzer, let me say, thank you so much for your time today, and also for the fantastic work you've done and continue to, it's been very informative for myself. So I appreciate that and I appreciate you taking the time to come and chat to me.

HERMAN PONTZER: Thanks so much for the invitation. It's been a great time talking. Thanks.